

Research Report

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EVALUATION OF THE FHWA HIGHWAY TRAFFIC NOISE PREDICTION
PROCEDURE (SNAP 1)

by

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offered for publication by the
Transportation Research Board

October 1980

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ABSTRACT

Traffic noise prediction procedures are used in the design of new highways to determine if noise is limited to specific levels. A previous study evaluated the procedure outlined in NCHRP Report 117 and developed a correction factor which was incorporated into Kentucky's noise prediction procedure. This adjusted NCHRP 117 procedure has been used in Kentucky for the past several years. The Federal Highway Administration has developed a new procedure to predict traffic noise levels. The objective of this study was to evaluate the new prediction procedure, designated as SNAP 1.

Comparisons of measured and predicted noise levels showed that predictions obtained from SNAP 1 yield better results than from the adjusted NCHRP 117 procedure. Therefore, it was recommended that the SNAP 1 prediction procedure be adopted. There is no need for a general correction factor; however, adjustments to specific portions of the procedure may be necessary to optimize the predictions.

INTRODUCTION

Policy and Procedure Memorandum 90-2 of the Federal Highway Administration directed that, after July 1, 1972, all highways constructed must conform to specific design noise levels (1). Several procedures have been developed to predict future noise levels of highways. The prediction procedure originally used in Kentucky was developed in NCHRP Report 117 (2). There were questions about the accuracy of this procedure and, therefore, an evaluation was conducted. The evaluation revealed significant discrepancies between measured and predicted values; a correction nomograph developed in this study was incorporated into Kentucky's procedure (3). This nomograph used roadway-to-receiver distance, truck volume per hour, and car speed to determine a correction factor to be applied to values as determined by the method outlined in NCHRP 117. Approval was granted by FHWA in October 1974.

Research has continued toward the objective of developing a more accurate procedure. A new procedure was reported in NCHRP 174 (4), and a traffic noise prediction model was developed by FHWA (5). FHWA then developed computer programs (6,7); these were called Simplified Noise Analysis Programs (SNAP). SNAP 1 is used for relatively simple site geometry while the FHWA Level 2 model is used for more complex situations. The objective herein was to evaluate the accuracy of SNAP 1.

PROCEDURE

To evaluate SNAP 1, it was necessary to obtain noise measurements and compare them to those predicted by SNAP 1. Data were taken at sites

having relatively simple geometry. Sites were selected near straight, level sections of roadway on unobstructed terrain so that the number of variables which might affect the evaluation would be minimal. All data were taken at a measurement height of 1.5 m (5 feet) over a ground cover of short grass. All data were taken in terms of dBA.

The majority of measurements were made with a precision sound level meter (Brüel and Kjaer Type 2209) and strip-chart recorder (Brüel and Kjaer Type 2306) (421 10-minute recordings). From the 10-minute recordings, noise levels at intervals slightly greater than one second were determined in the laboratory utilizing a digital data-reduction system. The output was punched onto computer cards through direct coupling with a card punch unit. By means of a computer program, the L10 and Leq noise levels were computed. The L10 noise level is the level exceeded 10 percent of the time and is the level currently used in federal traffic noise standards. The term Leq refers to the noise equivalent level. Additional data were taken with a noise level analyzer (Brüel and Kjaer Type 4426)(111 10-minute sets). A total of 532 10-minute data sets were used in the analysis.

Information about the traffic stream at the measurements sites is given in Table 1. Data were taken at six sites chosen so that data would be taken at locations offering a wide range in speeds, traffic volume, and truck volume.

Three predicted values were determined for each noise recording. First, the method outlined in NCHRP Report 117 was used to predict a value. Then the correction factor developed in the previous Kentucky research report (3) was applied to this value which yielded an adjusted NCHRP 117 value. Finally, SNAP 1 was used to predict the noise level.

Comparison of the difference between the measured and predicted values showed which prediction procedure was most accurate. The comparisons among the prediction procedures were based on L10 noise levels because only the SNAP 1 procedure yielded an Leq value. In addition, the measured Leq values were compared to the SNAP 1 predicted Leq values.

The average absolute difference between the measured noise level and predicted level was compared as a function of several variables. If this difference varied substantially as a given variable changed, it would mean that the variable in question had an effect on the error. For example, if the difference between the predicted and measured noise levels was much greater at short roadway-to-receiver distances, it would imply that a correction factor should be applied to data taken close to the roadway. Also, the average measured and predicted L10 noise levels for each variable range were determined.

RESULTS

A summary of data by test site is given in Table 2. The average speeds ranged from 16 m/s (36 mph) at Site 6 to 28 m/s (62 mph) at Site 3. The average total volume (vehicles per hour) ranged from 485 at Site 5 to 4,030 at Site 4. The total volume was divided into automobiles, medium trucks, and heavy trucks, as required by the procedure outlined in SNAP 1. Medium trucks are defined as vehicles having two axles and six tires; Heavy trucks have three or more axles. There was a very large range in heavy truck volume--245 per hour at Site 3 to 8 at Site 5. These two vehicle types are considered the same when NCHRP 117 is used.

The average actual L10 noise level as well as the average of the

three predicted L10 values, is given in Table 2, by site. The discrepancies previously reported with the NCHRP 117 procedure manifested again as overpredictions at every site. The largest differences were found at sites having low truck volumes and speeds. The maximum difference between the average predicted and measured noise levels was an overprediction of almost 10 dBA at Site 6. Again improvement in the predictions with the adjusted NCHRP 117 procedure resulted. The correction factor improved the average predicted value at each site and provided a very significant improvement at some of the sites. However, the predictions obtained from the SNAP 1 procedure provided the best results. For example, at Site 6, the NCHRP 117 procedure overpredicted the measured value by 9.5 dBA. The correction factor reduced this error in average values to 3.2 dBA, but the error in the SNAP 1 procedure was only 0.5 dBA. Considering the average of all measurements, there was a difference of 4.7 dBA between the measured and predicted L10 NCHRP 117 noise levels. This difference was reduced to 1.0 dBA by the correction factor applied to results from the NCHRP 117 procedure. However, the difference between the average measured and SNAP 1 predicted L10 noise levels was only 0.1 dBA.

The average absolute difference between measured and predicted noise levels were also determined (Table 3). These data also showed that SNAP 1 provided the best results and that the procedure in NCHRP 117 gave the worst results. The average difference for all sites was 5.0 dBA by the NCHRP 117 procedure. This difference was decreased to an average of 3.0 dBA by the correction factor. The smallest difference was 2.1 dBA when SNAP 1 was used. The difference between measured and SNAP 1 values were very similar for the L10 and Leq values.

The distribution of the differences between measured and predicted L10 values was summarized for each prediction procedure in Table 4. The problem with the NCHRP procedure was that it overpredicted in 90 percent of the cases, and the overprediction was by 5 dBA or more in almost 50 percent of the cases. There was still a tendency to overpredict with the adjusted NCHRP procedure. The overprediction was in 64 percent of the cases, but the percentage of cases with a difference of 5 dBA or more was reduced by 60 percent. SNAP 1 L10 predictions were equally distributed above and below the measured noise levels. There was a slight tendency for the SNAP 1 procedure to overpredict the Leq levels; that is, in 56 percent of the cases. The large differences were reduced substantially using SNAP 1; that is, there was a difference of less than 3 dBA in about 75 percent of the cases.

The distribution of differences between measured and predicted L10 values for each of the six sites was analyzed. The major differences between measured and SNAP 1 predicted noise levels occurred at two sites. SNAP 1 underpredicted at Site 3. Site 3 was unique in that it had a very high proportion of heavy trucks. The large differences occurred when the measured noise was particularly high (over 80 dBA). Site 2 had very low volumes, and large differences occurred when data were taken at large distances from the roadway where noise levels were very low. At these very low volume locations, the 10 minute sample periods could have been inadequate. Also, the L10 parameter breaks down in usefulness at very low traffic volumes.

A comparison was made between measured and predicted L10 levels as a function of the magnitude of the measured noise level (Table 5). The largest differences between measured and SNAP 1 predicted values

occurred when the actual L10 level was either very low (less than 55 dBA) or very high (80 dBA or above). The SNAP 1 procedure overpredicted at the very low level and underpredicted at the very high level. Measured and SNAP 1 predictions were very close for levels measured between 55 and 80 dBA. The NCHRP predictions became better as the measured noise level increased and was better than SNAP 1 predictions when the measured L10 level was 80 dBA or above.

The SNAP 1 procedure also enables prediction of the Leq level. The measured Leq level was compared to the SNAP 1 value as shown in Table 6. The overall average measured and predicted Leq levels were very close. When measured and predicted Leq levels were compared site by site, the largest difference in average values was only 1.5 dBA.

In the previous evaluation of the NCHRP procedure, discrepancies found between predicted and measured noise levels were related to certain factors (3). These factors were then used to develop the correction nomograph. Herein, comparisons of the difference between measured and predicted values have been made for the following variables:

- (1) traffic volume
- (2) automobile volume
- (3) truck volume
- (4) heavy truck volume
- (5) medium truck volume
- (6) roadway-to-receiver distance

As was learned earlier (3), the difference between measured and NCHRP 117 levels varied with distance and truck volume, specifically heavy truck volume: the difference was greater at close distances and

low heavy truck volumes. This did not occur with the adjusted NCHRP 117 values. None of the other variables showed a definite relationship between the difference in the measured and predicted values. There did not appear to be a relationship between any of the variables and the difference between measured and SNAP 1 levels.

The average measured and predicted noise levels were determined as a function of each variable. The results clearly showed that the NCHRP 117 procedure consistently overpredicted noise. This overprediction became worse at close roadway-to-receiver distances, low truck volumes, and low speeds. The error associated with the adjusted NCHRP 117 procedure was substantially lower; however, the remaining error was still consistently an overprediction. The SNAP 1 procedure did not either consistently overpredict or underpredict noise.

There was an overall difference between measured and SNAP 1 values of 2 dBA (Table 3). Differences of around 2 dBA existed for each of the variables tested; however, when average measured and SNAP 1 values were compared for each variable, there was a very close agreement. Since the average values were in agreement, much of the 2 dBA difference may be attributable to errors in data collection.

RECOMMENDATION

It was recommended that the SNAP 1 prediction procedure be adopted and it was adopted for use in Kentucky starting January 1, 1980. There is no need for a general correction factor; however, adjustments to specific portions of the procedure may be necessary to optimize the results. For example, reference vehicle noise emission levels need to be determined specifically for Kentucky vehicles to replace the

nationwide levels currently used in the prediction methodology. The new emission levels can be input into the prediction procedure to determine the effect on its accuracy. Also, adjustment factors for different textures of pavement need to be applied (8). It is recommended that these adjustments be incorporated into the SNAP 1 procedure.

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TABLE 1. TRAFFIC NOISE MEASUREMENT SITES

SITE NUMBER	ROUTE	LOCATION (CITY)	HIGHWAY NAME	TYPE OF LOCATION	SPEED LIMIT MPH (M/S)	AVERAGE SPEED MPH (M/S)	NUMBER OF 10-MINUTE MEASUREMENTS
1	US27	LEXINGTON	SOUTH LIMESTONE STREET	URBAN	40(18)	37(17)	120
2	US68	LEXINGTON	HARRISBURG ROAD	RURAL	55(25)	54(24)	90
3	175	LEXINGTON	INTERSTATE 75	RURAL	55(25)	62(28)	123
4	1264	LOUISVILLE	WATTERSON EXPRESSWAY	RUBAN	55(25)	48(21)	99
5	US60	LEXINGTON	WINCHESTER ROAD	RURAL	55(25)	53(24)	58
6	US31W	LOUISVILLE	DIXIE HIGHWAY	URBAN	40(18)	36(16)	42

TABLE 2. SUMMARY OF DATA BY TEST SITE

SITE NUMBER	AVERAGE VOLUMES (VPH)					SPEED LIMIT MPH (M/S)	AVERAGE PREDICTED L10 NOISE LEVELS (DBA)			AVERAGE MEASURED L10 NOISE LEVEL (DBA)	NUMBER OF MEASUREMENTS
	TOTAL	AUTO	MEDIUM TRUCK	HEAVY TRUCK	TOTAL TRUCK		PREDICTION PROCEDURE				
							NCHRP-117	ADJUSTED NCHRP-117	SNAP-1		
1	2110	2064	41	6	47	40 (18)	69.0	61.5	62.9	62.9	120
2	519	477	27	16	43	55 (25)	68.6	64.3	64.1	64.3	90
3	1469	1153	70	245	315	55 (25)	74.9	74.4	71.5	72.9	123
4	4030	3701	150	180	330	55 (25)	79.3	78.1	74.9	73.3	99
5	484	453	22	8	30	55 (25)	65.8	62.0	62.9	63.8	58
6	2925	2740	127	64	191	40 (18)	77.7	71.4	68.7	68.2	42
OVERALL	1937	1767	70	100	170	DNA	72.5	68.9	67.8	67.9	532

Table 3. Average, Absolute Difference Between
Measured and Predicted Noise Levels

AVERAGE ABSOLUTE DIFFERENCE BETWEEN MEASURED AND PREDICTED NOISE LEVELS (DBA)				
PREDICTION PROCEDURE				
SITE NUMBER	NCHRP-117 (L10)	ADJUSTED NCHRP-117 (L10)	SNAP 1	
			L10	LEQ
1	6.1	2.5	1.8	1.8
2	4.4	2.1	2.5	2.4
3	3.0	2.8	2.5	2.5
4	6.1	4.8	2.0	1.7
5	3.2	3.0	2.0	1.8
6	9.5	3.5	1.4	1.4
ALL SITES	5.0	3.0	2.1	2.0

TABLE 4. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP 117(L10)	ADJUSTED NCHRP 117(L10)	SNAP 1		NCHRP 117(L10)	ADJUSTED NCHRP 117(L10)	SNAP 1	
			L10	LEQ			L10	LEQ
LESS THAN 1.0	18	44	65	64	23	46	65	74
1.0 - 1.9	14	40	60	57	40	64	76	72
2.0 - 2.9	8	35	62	55	46	42	63	73
3.0 - 3.9	4	28	39	34	52	50	35	40
4.0 - 4.9	4	27	21	13	64	44	13	24
5.0 OR ABOVE	4	27	14	5	255	77	10	14

* THE MEASURED AND PREDICTED L10 NOISE LEVELS WERE EQUAL IN 8 CASES FOR THE ADJUSTED NCHRP-117 AND 9 CASES FOR SNAP 1 PREDICTION PROCEDURES. THEY WERE NEVER EQUAL USING THE NCHRP-117 PROCEDURE. THE ACTUAL AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN 7 CASES USING THE SNAP 1 PROCEDURE.

TABLE 5. COMPARISON OF MEASURED AND PREDICTED L10 NOISE LEVELS AS A FUNCTION OF THE MAGNITUDE OF THE MEASURED NOISE LEVEL

MEASURED NOISE LEVEL (DBA)	NUMBER OF MEASUREMENTS	AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED (DBA)			AVERAGE L10 NOISE LEVEL (DBA)			
		PREDICTION PROCEDURE USED			SNAP 1	NCHRP-117	ADJUSTED NCHRP-117	MEASURED
		NCHRP-117	ADJUSTED NCHRP-117	SNAP 1				
LESS THAN 55	11	5.0	2.9	3.4	56.7	58.6	56.4	53.6
55 - 59.9	46	5.0	2.1	2.0	58.8	63.0	58.4	58.3
60 - 64.9	125	5.2	2.6	2.0	63.5	67.8	62.6	62.8
65 - 69.9	161	5.2	3.3	1.8	67.6	72.4	68.3	67.4
70 - 74.9	92	5.1	3.2	2.4	71.4	77.1	74.4	72.5
75 - 79.9	77	4.9	3.6	3.3	76.5	81.8	80.1	77.5
80 OR ABOVE	20	3.2	3.2	3.3	77.8	81.7	80.0	81.0

TABLE 6. COMPARISON OF MEASURED
LEQ NOISE LEVEL WITH
PREDICTED VALUE (SNAP 1)

SITE NUMBER	LEQ NOISE LEVEL (DBA)	
	MEASURED	PREDICTED
1	60.7	61.0
2	61.4	62.9
3	69.4	68.2
4	70.6	71.8
5	60.3	60.9
6	65.5	65.7
ALL	65.0	65.4